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Byun et al.

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(54) **RECHARGEABLE BATTERY**

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H01M 10/34 (2006.01)
H01M 10/52 (2006.01)

(52) **U.S. Cl.** **429/59**; 429/53; 429/56; 429/57; 429/60

(58) **Field of Classification Search** 429/57, 429/58, 53–56, 61, 59
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,523,178	A	6/1996	Murakami et al.	
5,707,756	A *	1/1998	Inoue et al.	429/57
2007/0166605	A1 *	7/2007	Meguro et al.	429/61
2011/0135976	A1 *	6/2011	Byun	429/56

FOREIGN PATENT DOCUMENTS

EP	1 076 350 A2	2/2001
JP	06-290767	10/1994
JP	09-106804	4/1997
JP	10-326610	12/1998
JP	11-007931	1/1999
JP	3232767	9/2001

OTHER PUBLICATIONS

Patent Abstract of Japan for Publication No. 06-290767 dated Oct. 18, 1994 corresponding to Japanese Patent No. 3232767 referenced above.

Patent Abstracts of Japan and English machine translation for publication No. JP 10-326610, dated Dec. 8, 1998 in the name of Kobayashi.

(Continued)

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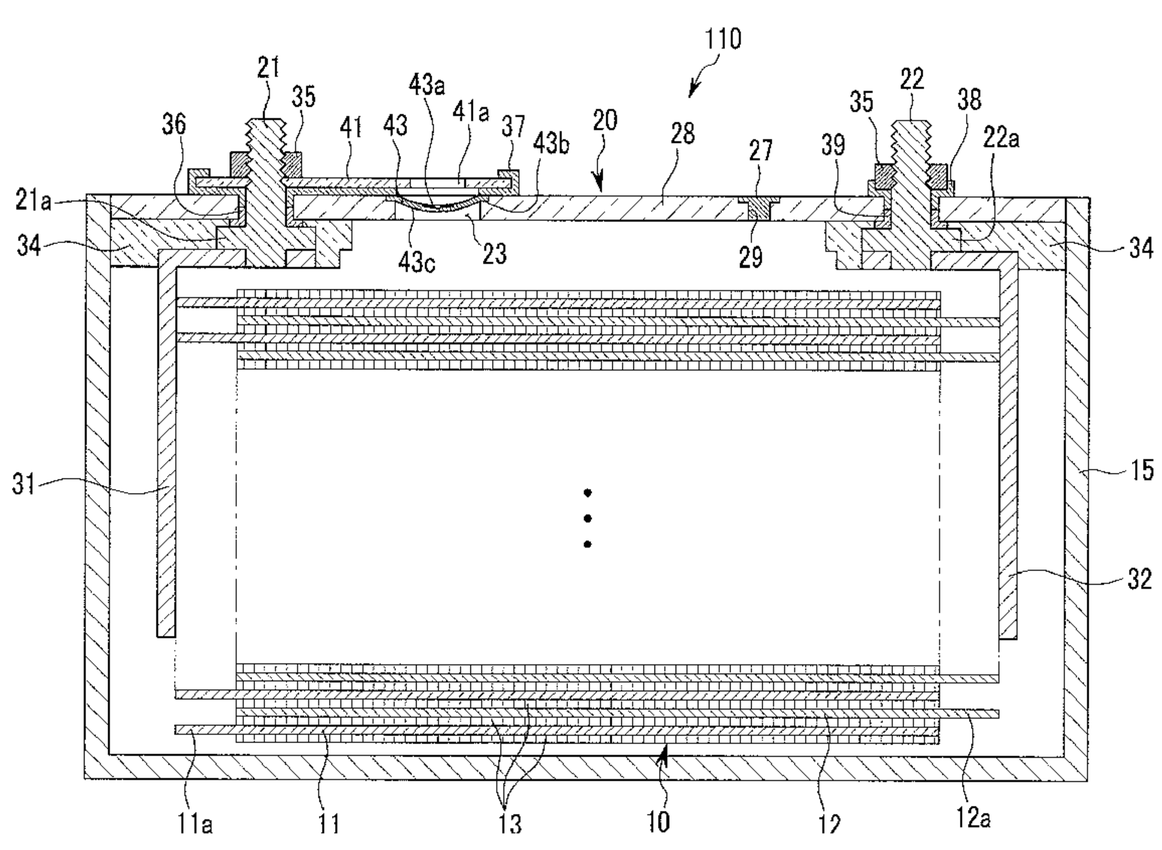
(57) **ABSTRACT**

A rechargeable battery according to an exemplary embodiment of the present invention includes an electrode assembly, a case containing the electrode assembly, and a cap assembly. The electrode assembly includes a first electrode, a second electrode, and a separator between the first and second electrodes. The cap assembly is coupled to the case. The cap assembly includes a tab that is electrically connected to the first electrode and a deformable plate that is electrically connected to the second electrode. The deformable plate also includes a notch that is opened due to an increase of pressure. The deformable plate deforms as a result of increased pressure and electrically contacts the first tab, short circuiting the rechargeable battery.

17 Claims, 9 Drawing Sheets



OTHER PUBLICATIONS

Patent Abstracts of Japan and English machine translation for publication No. JP 11-007931, dated Jan. 12, 1999 in the name of Kobayashi.

Extended European Search Report dated Oct. 13, 2010 in corresponding European application No. 10169791, listing the cited references in this IDS.

European Search Report dated Apr. 21, 2011, for corresponding European Patent application 10169791.0, noting listed reference in this IDS, as well as references previously submitted in an IDS dated Nov. 24, 2010.

KIPO Office action dated Jan. 17, 2012, for corresponding Korean Patent application 10-2010-0068019, 9 pages, Not in English. Acknowledged.

Patent Abstracts of Japan and English machine translation for Japanese Publication 06-290767 listed above, 13 pages.

* cited by examiner

FIG.1

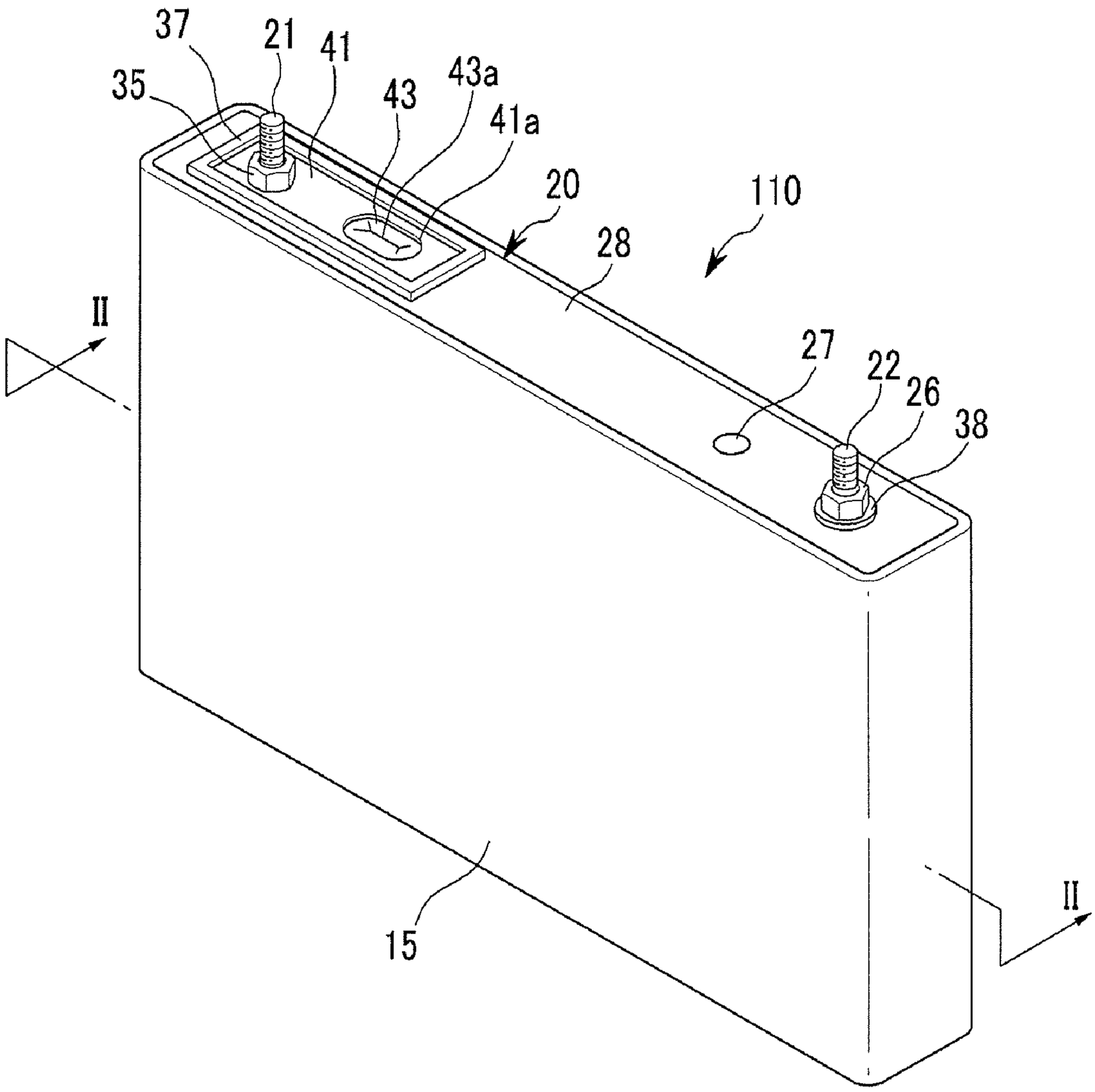
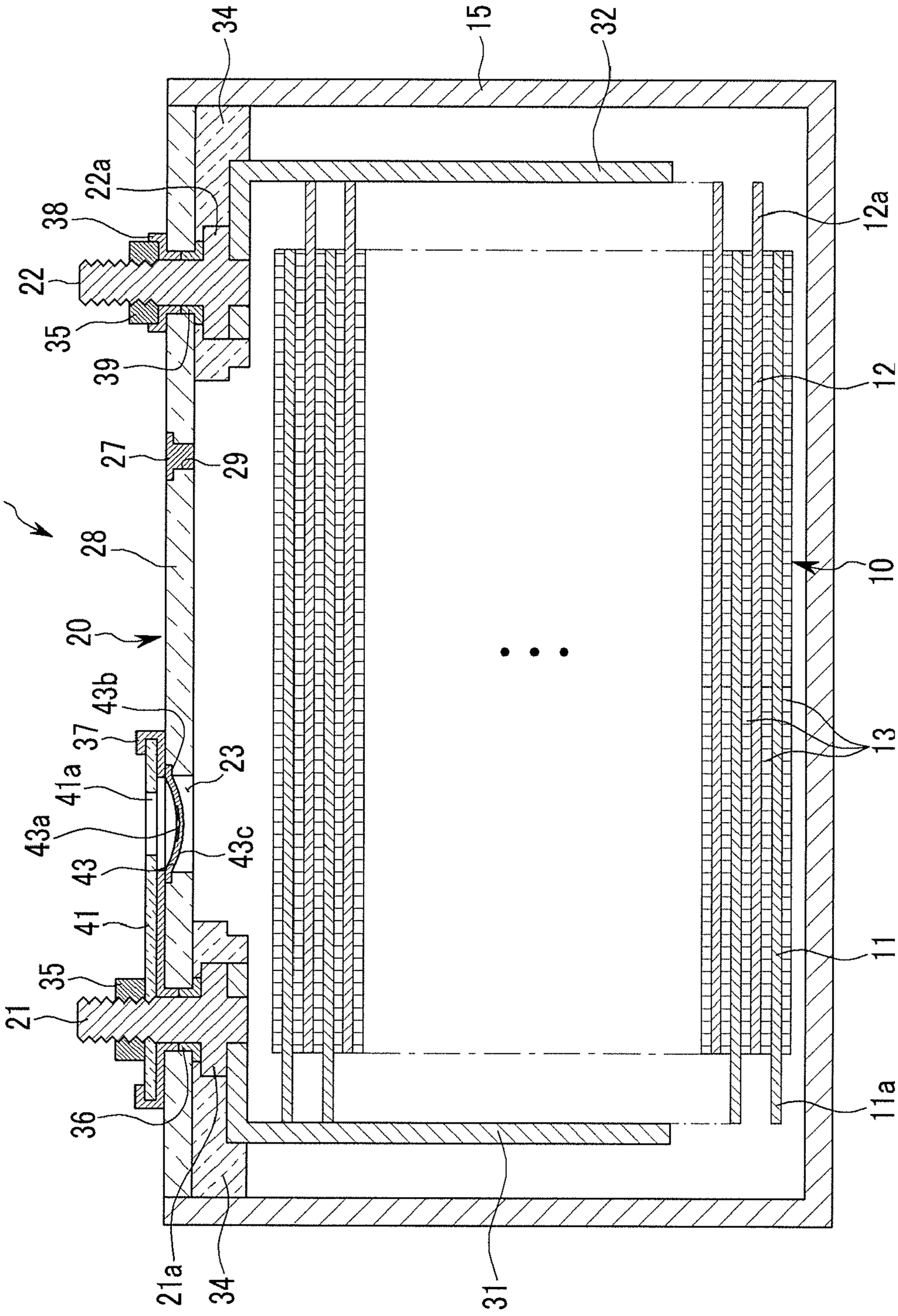


FIG.2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15
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22a
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110
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43b
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23
41a
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43c
43
41
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21
36
21a
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31
12a
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13
11
11a

FIG.3A

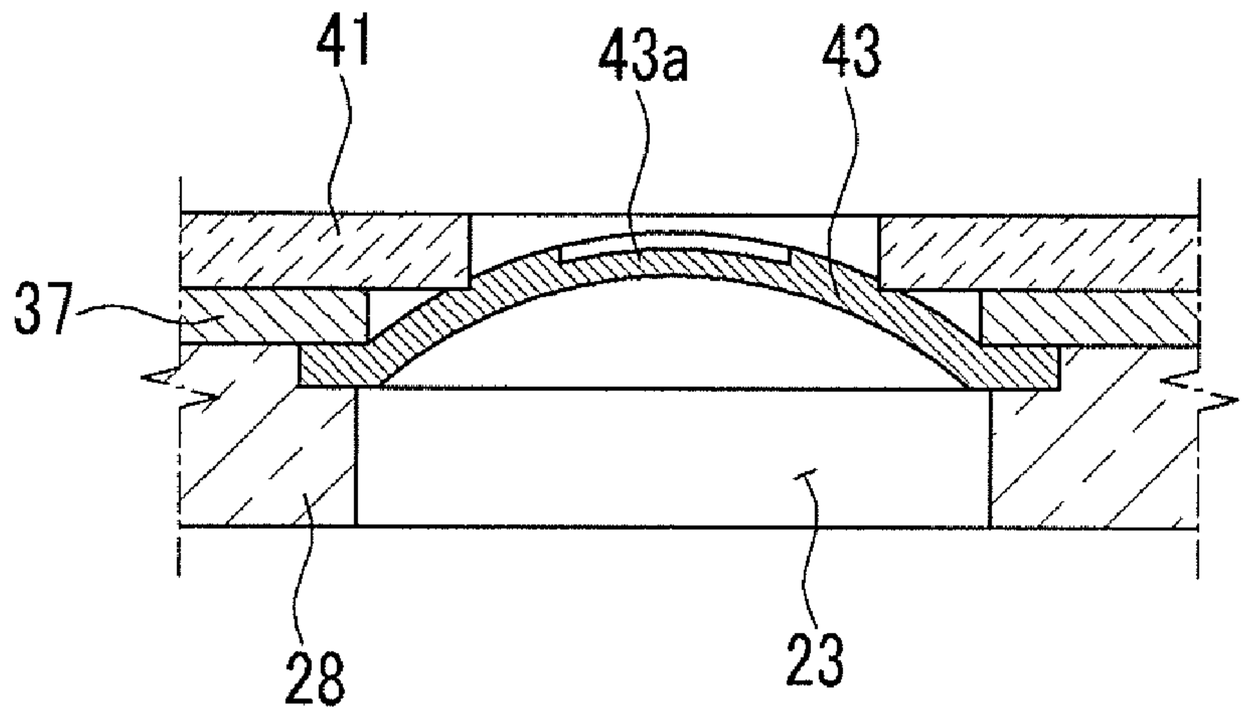


FIG.3B

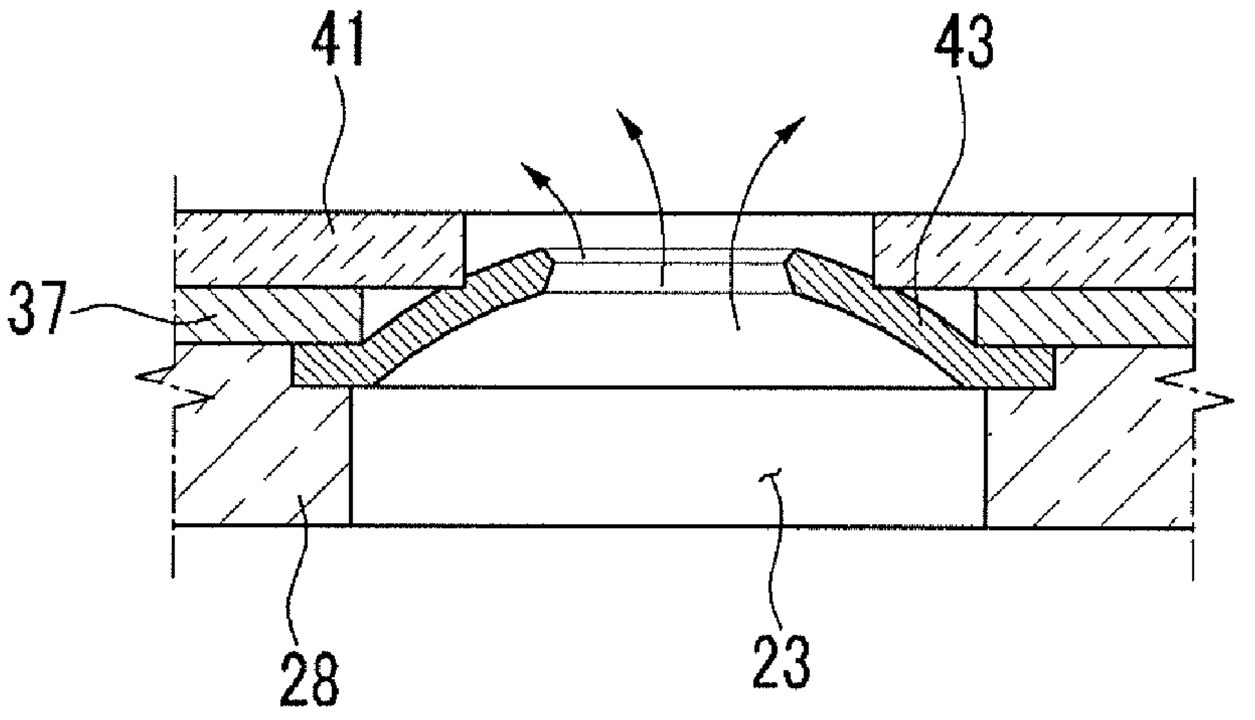
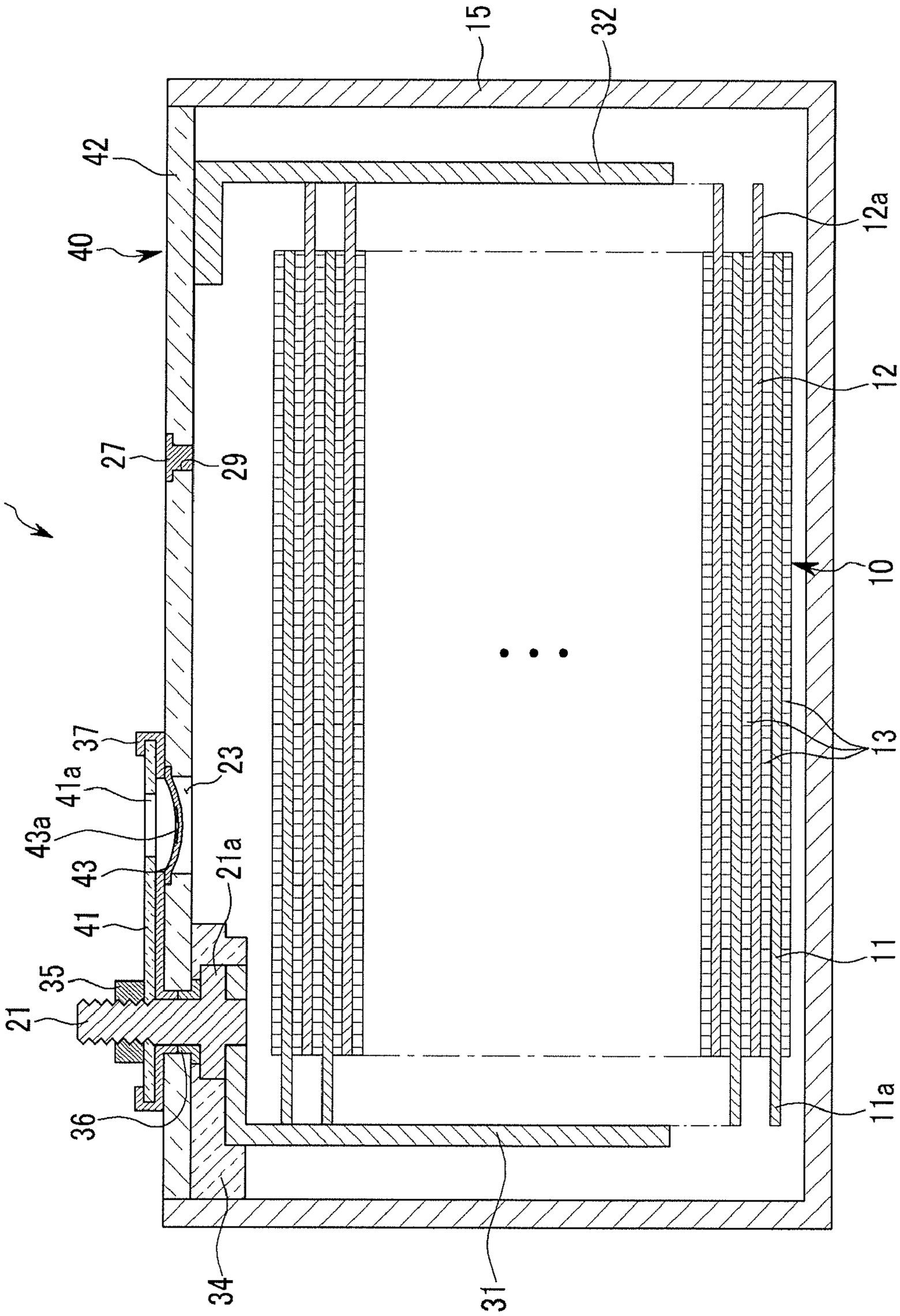


FIG.4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32
42
40
12a
12
27
29
120
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37
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41a
43a
43
21a
41
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36
13
11
11a
34
31

FIG.5

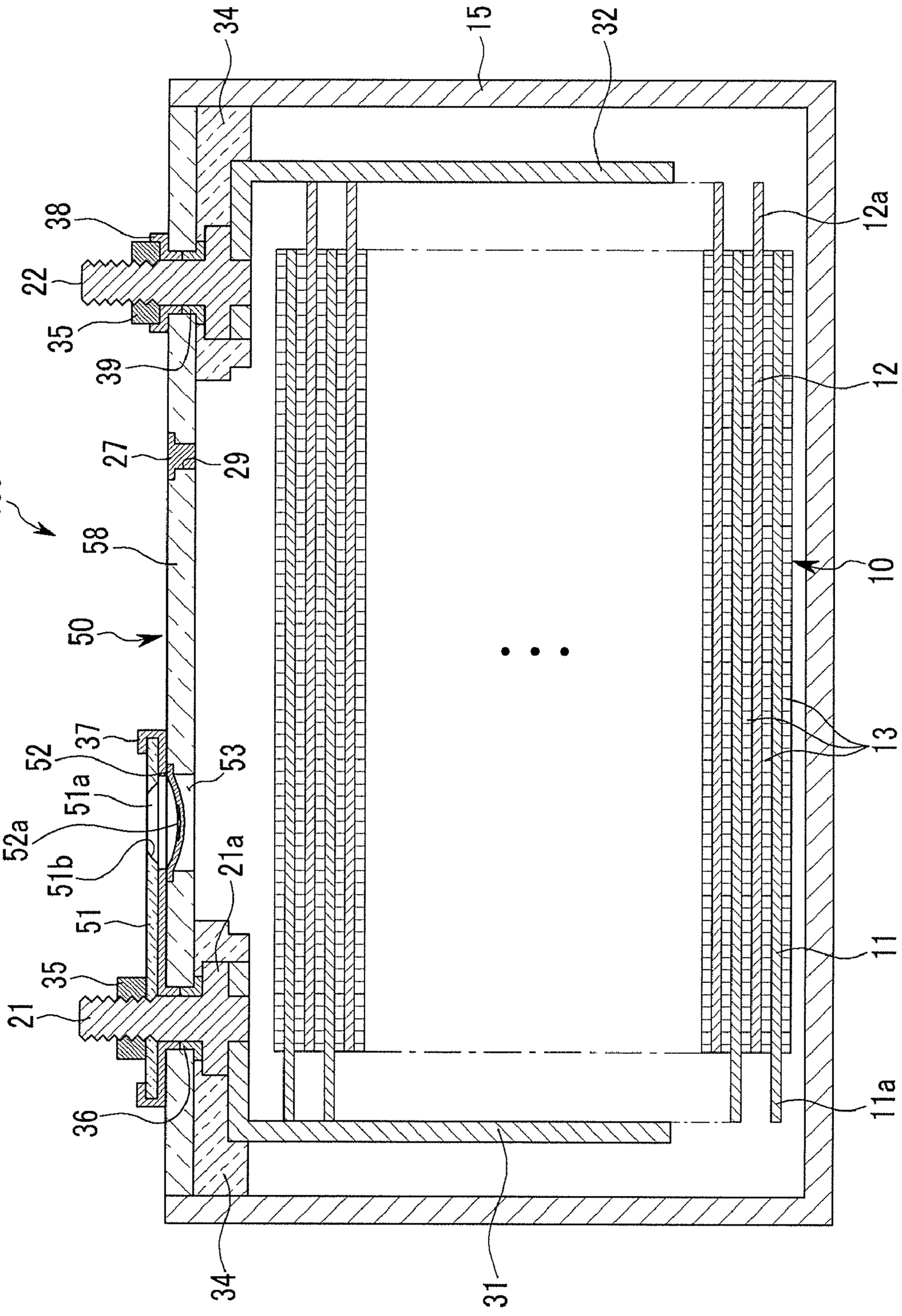
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FIG.6A

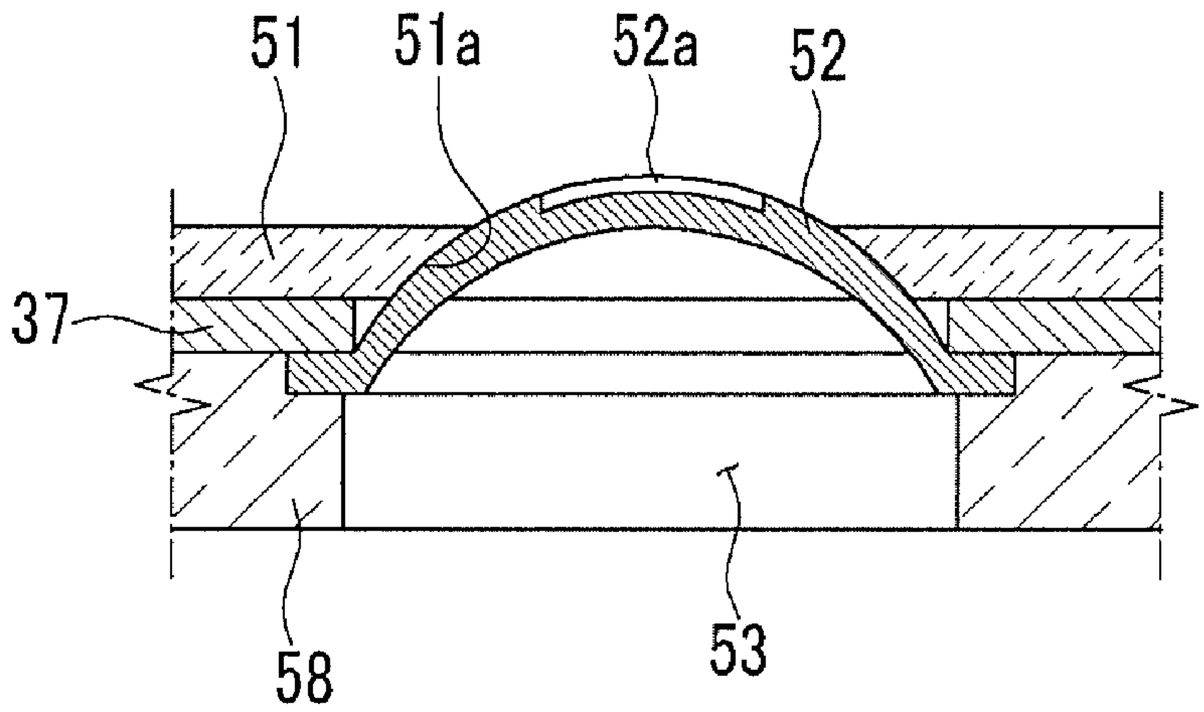


FIG.6B

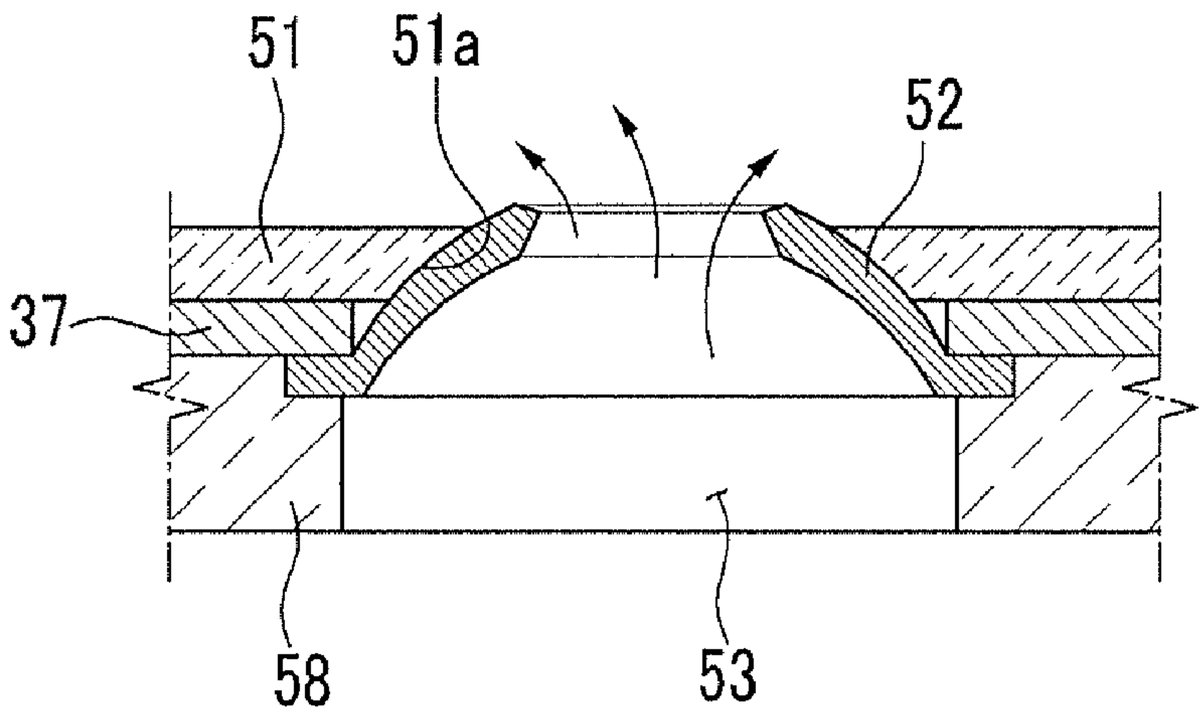
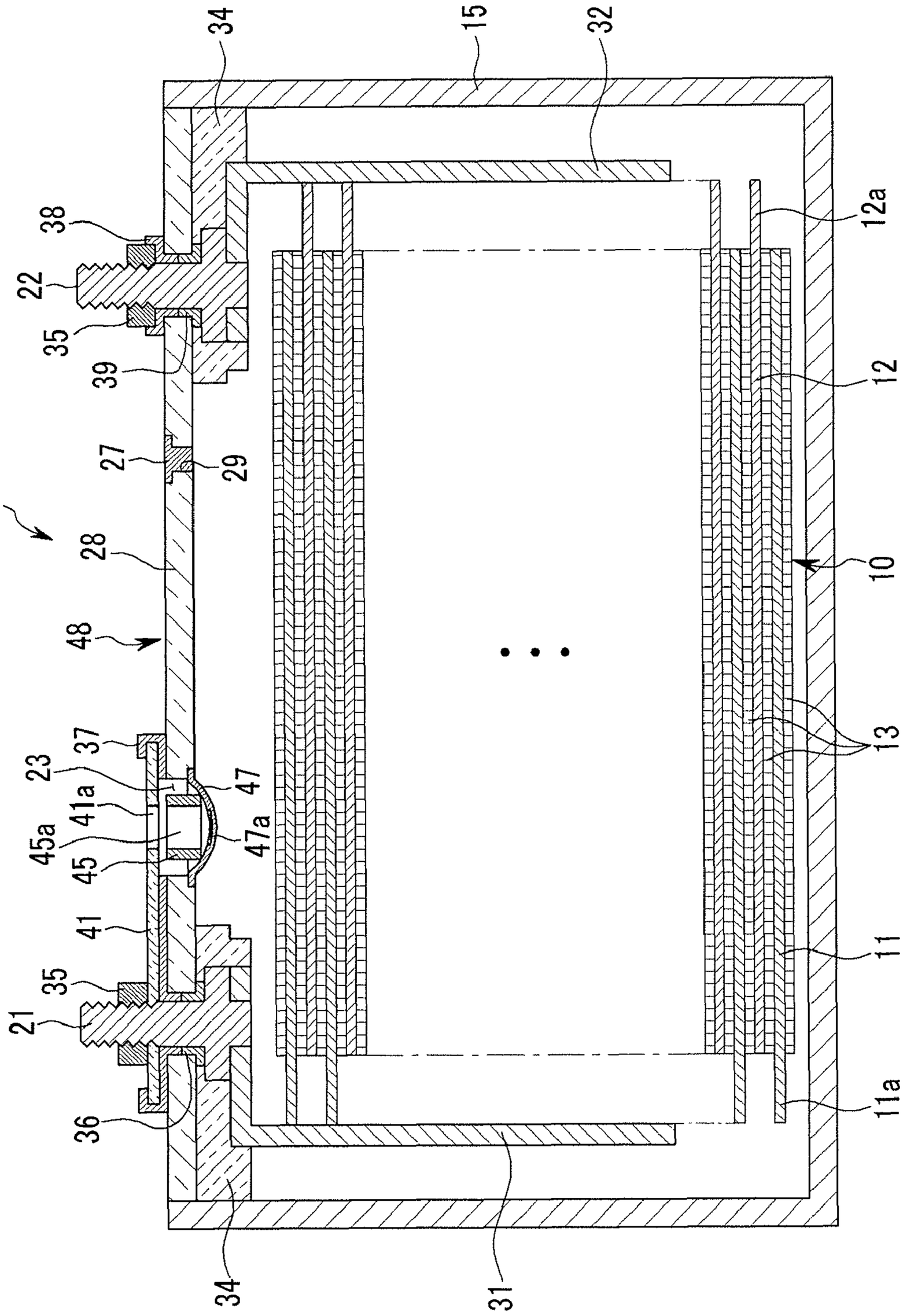


FIG.7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11a
34
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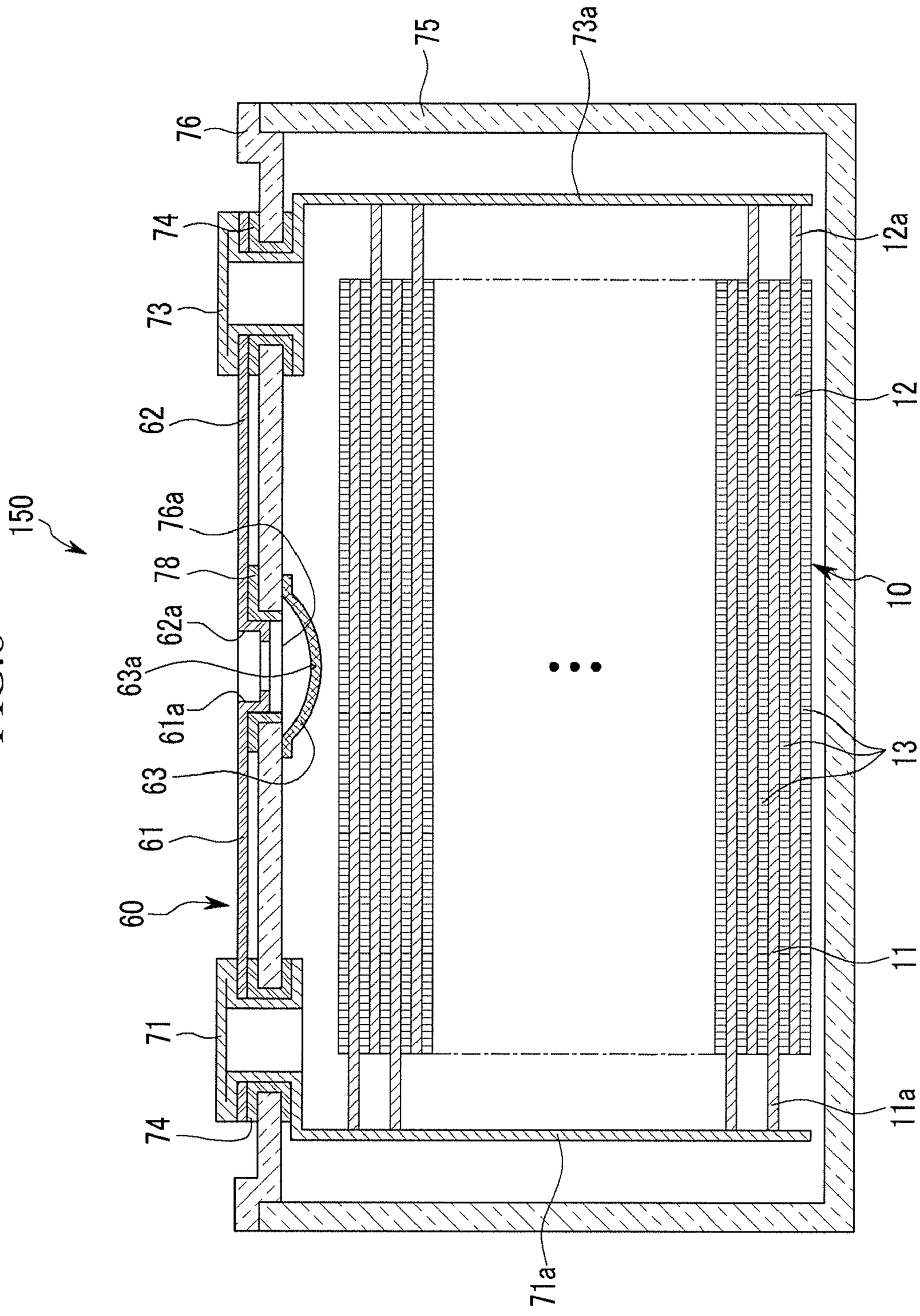
FIG.8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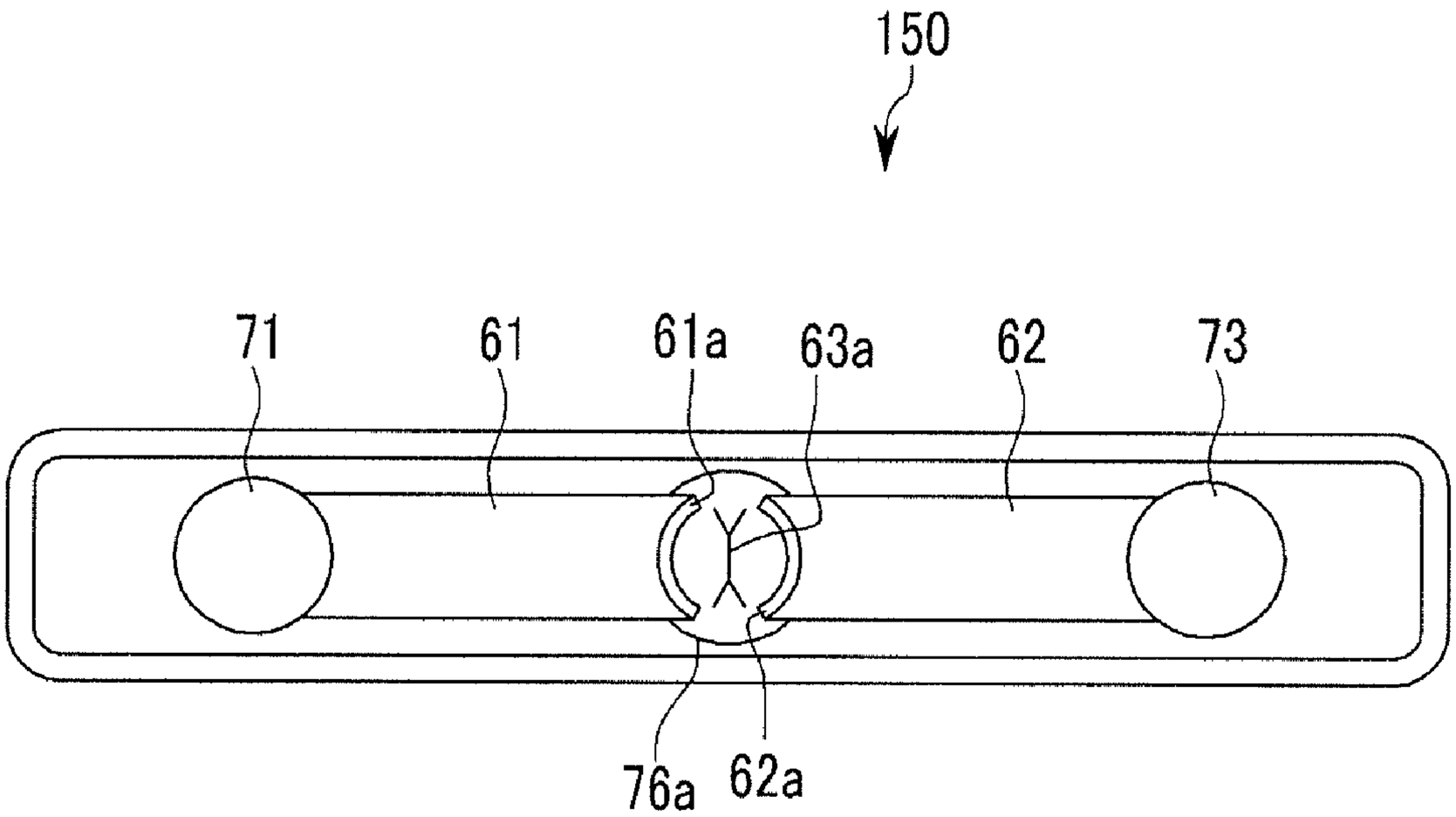
11a

FIG.9



RECHARGEABLE BATTERY

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to and the benefit of U.S. Provisional Application No. 61/234,117, filed on Aug. 14, 2009, in the United States Patent and Trademark Office, the entire content of which is incorporated herein by reference.

BACKGROUND

1. Field

The following description relates to a rechargeable battery, and more particularly to a rechargeable battery having a safety apparatus that can prevent or reduce the chance of an explosion when a rechargeable battery is overcharged.

2. Description of the Related Art

Unlike a primary battery that is not designed to be recharged, a rechargeable battery can be repeatedly charged and discharged. Low-capacity rechargeable batteries are used for portable compact electronic apparatuses such as mobile phones, notebook computers, and camcorders, and high-capacity rechargeable batteries are widely used as a power source for driving a motor of a hybrid vehicle, etc.

A high-output rechargeable battery using a non-aqueous electrolyte having high energy density has been recently developed. The high-output rechargeable battery is configured to have high capacity by connecting a plurality of rechargeable cells in series so that it can be used for driving a motor for an apparatus requiring a large amount of power, i.e., an electrical vehicle, etc.

One large-capacity rechargeable battery is commonly formed with a plurality of rechargeable batteries coupled in series. The rechargeable battery may, have a cylindrical shape or prismatic shape.

The prismatic rechargeable battery includes an electrode assembly that has a positive electrode and a negative electrode with a separator interposed therebetween, a case having a space for containing the electrode assembly, a cap plate that seals the case and has a terminal hole into which an electrode terminal is inserted, and an electrode terminal that is electrically connected with the electrode assembly and is inserted into the terminal hole of the cap plate, the terminal protruding out of the case.

When excessive heat is generated inside the rechargeable battery or internal pressure is increased due to dissolution of an electrolyte solution, the battery may explode or combust. Particularly, in the case of the prismatic battery, due to the characteristics of its terminal structure, it is difficult to have a structure that cuts off or discharges current when heat and pressure are increased, especially when compared to the cylindrical battery.

The above information disclosed in this Background section is only for enhancement of understanding of the background of the described technology and therefore it may contain information that does not form the prior art that is already known in this country to a person of ordinary skill in the art.

SUMMARY

An aspect of an embodiment of the present invention is directed toward a rechargeable battery having improved safety.

According to an exemplary embodiment of the present invention, a rechargeable battery includes an electrode assembly including a first electrode, a second electrode, and a separator between the first electrode and the second electrode, a case containing the electrode assembly, and a cap assembly coupled to the case. The cap assembly includes a cap plate, a first tab electrically coupled to the first electrode, and a deformable plate including a notch.

The deformable plate may be configured to form an electrical path between the first electrode and the second electrode when deformed. The deformable plate may be configured to deform and be electrically coupled with the first tab in response to an increase in pressure inside the case to electrically couple the first electrode and the second electrode to each other. The deformable plate may be electrically coupled to the cap plate. The deformable plate may be welded to the cap plate.

The cap assembly may further include an insulating member between the first tab and the cap plate for electrically insulating the first tab from the cap plate. The cap assembly may further include a first terminal electrically coupled to the first electrode and mounted on the cap plate, wherein the first tab is electrically connected to the first terminal. The first tab may have an opening through which the first terminal protrudes from an interior to an exterior of the case. The first tab may be fixed to the cap plate by an enlarged head of the first terminal or a nut coupled to the first terminal. The cap plate may have a short circuit opening covered by the deformable plate. The cap assembly may further include an insulating member between the first tab and the cap plate for electrically insulating the first tab from the cap plate, wherein the insulating member includes an opening to accommodate upward deformation of the deformable plate. The first tab may include a protrusion which is at least partially inserted into the short circuit opening.

The second electrode may be electrically coupled to the cap plate. The cap assembly may further include a second terminal, and the second electrode may be electrically coupled to the second terminal.

The deformable plate may be curved to protrude toward an inside of the case. The deformable plate may be configured to break and open at the notch in response to an increase in pressure inside the case.

The first tab may have a vent hole. A diameter of the vent hole may decrease from the interior of the case toward the exterior of the case. The rechargeable battery may further include a middle member between the first tab and the deformable plate, the middle member being attached to the deformable plate.

The rechargeable battery may further include a first terminal, a second terminal, and a second tab, the first tab may be connected to the first terminal and the second tab may be connected to the second terminal. The rechargeable battery may further include a deformable plate configured to deform and electrically contact the first tab and the second tab in response to an increase in pressure inside the case. The cap plate may have a short circuit opening, wherein a first end of the first tab may be connected to the first terminal and a second end of the first tab may be in the short circuit opening and a first end of the second tab may be connected to the second terminal and a second end of the second tab may be in the short circuit opening.

An exemplary embodiment of the present invention includes a rechargeable battery having an electrode assembly comprising a first electrode, a second electrode, and a separator between the first electrode and the second electrode, a case containing the electrode assembly, and a cap assembly coupled to the case. The cap assembly may include a cap plate, a first tab electrically coupled to the first electrode, and

a deformable plate configured to deform and break to allow gas to exit the case. The cap plate may include a vent hole configured to allow gas to exit the case when the deformable plate breaks. The deformable plate may include a first portion and a second portion, the second portion being thinner than the first portion.

An exemplary embodiment of the present invention includes a rechargeable battery having an electrode assembly including a first electrode, a second electrode, and a separator between the first electrode and the second electrode, a case containing the electrode assembly, and a cap assembly coupled to the case. The cap assembly may include a cap plate, a first tab electrically coupled to the first electrode, the first tab having an opening and a deformable plate positioned to allow the gas to escape through the opening when the deformable plate is broken.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a rechargeable battery according to a first exemplary embodiment of the present invention.

FIG. **2** is a cross-sectional view of FIG. **1**, taken along the line II-II.

FIG. **3**A is a cross-sectional view depicting a deformed deformable plate and a short tab according to the first exemplary embodiment of the present invention, and FIG. **3**B is a cross-sectional view depicting a broken notch according to the first exemplary embodiment of the present invention.

FIG. **4** is a cross-sectional view of a rechargeable battery according to a second exemplary embodiment of the present invention.

FIG. **5** is a cross-sectional view of a rechargeable battery according to a third exemplary embodiment of the present invention.

FIG. **6**A is a cross-sectional view depicting a deformed deformable plate and a first tab according to the third exemplary embodiment of the present invention, and FIG. **6**B is a cross-sectional view depicting a broken notch according to the third exemplary embodiment of the present invention.

FIG. **7** is a cross-sectional view of a rechargeable battery according to a fourth exemplary embodiment of the present invention.

FIG. **8** is a cross-sectional view of a rechargeable battery according to a fifth exemplary embodiment of the present invention.

FIG. **9** is a top view of the rechargeable battery according to the fifth exemplary embodiment of the present invention.

DESCRIPTION OF REFERENCE NUMERALS INDICATING SOME ELEMENTS IN THE DRAWINGS

110:	rechargeable battery
10:	electrode assembly
11:	first electrode
12:	second electrode
13:	separator
15:	case
20:	cap assembly
21:	first terminal
22:	second terminal
23:	short circuit opening
28:	cap plate
34:	lower insulation member
35:	nut
37:	upper insulation member
38:	connection tab
41:	first tab
41a:	vent hole
43:	deformable plate
43a:	notch
43b:	frame portion
43c:	deformed portion
45:	middle member

DETAILED DESCRIPTION

Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings such that those having ordinary skill in the art to which the present invention pertains may easily implement the technological concept of the present invention. However, the present invention may be implemented in various different ways, and is not limited to the following exemplary embodiments. Like reference numerals designate like constituent elements throughout the specification.

As described herein, "deformable plate" may include all types of plates that are capable of being deformed in response to a pressure increase. The shape of the plate is not limited to the described embodiments, rather any suitable plate shape may be used.

FIG. **1** is a perspective view of a rechargeable battery **110** according to a first exemplary embodiment of the present invention, and FIG. **2** is a cross-sectional view of FIG. **1**, taken along the line II-II. Referring to FIG. **1** and FIG. **2**, a rechargeable battery **110** according to the present exemplary embodiment includes an electrode assembly **10** that is wound with an insulating separator **13** disposed between a first electrode **11** and a second electrode **12**, a case **15** in which the electrode assembly **10** is contained, and a cap assembly **20** coupled to an opening of the case **15**.

The rechargeable battery **110** according to the first exemplary embodiment is a prismatic lithium ion secondary battery. However, the present invention is not limited thereto, and the present invention may be applied to various types of batteries such as a lithium polymer battery or a cylindrical lithium ion secondary battery.

The first electrode **11** and the second electrode **12** include coated regions and uncoated regions on a current collecting body that is formed of a thin plate metal foil. The coated regions are coated with an active material and the uncoated regions are not coated with the active material. In the present exemplary embodiment, the first electrode **11** is a positive electrode and the second electrode **12** is a negative electrode. However, the present invention is not limited thereto. Therefore, the first electrode **11** may be a negative electrode and the second electrode **12** may be a positive electrode.

A first electrode uncoated region **11***a* is formed at one side of the first electrode **11** along a length direction of the first electrode **11**, and a second electrode uncoated region **12***a* is formed at one side of the second electrode **12** along a length direction of the second electrode **12**. In addition, a separator **13**, which is an insulator, is between the first electrode **11** and the second electrode **12**. The first electrode **11**, second electrode **12**, and separator **13**, are then spirally wound.

Alternatively, the electrode assembly **10** may have a structure in which the first and second electrodes **11** and **12**, formed of a plurality of sheets, are alternately stacked, such as in a lithium polymer battery.

The case **15** is substantially formed as a cuboid, or a rectangular box, and an opening is formed on one side thereof. The cap assembly **20** includes a cap plate **28** covering the opening of the case **15**, a first terminal **21** protruding out of the cap plate **28**, the first terminal **21** electrically connected to the first electrode **11**. The cap assembly **20** may also include a second terminal **22** electrically connected to the second electrode, a first tab **41** electrically connected to the first terminal **21**, and a deformable plate **43** electrically connected to the second terminal **22** and contacting the first tab **41** when deformed.

The cap plate **28** is formed of a thin plate and combined to the opening of the case **15**. The cap plate **28** includes a sealing cap **27** formed in an electrolyte injection opening **29**.

The first terminal **21** and the second terminal **22** extend through the cap plate **28**, and each of the first terminal **21** and second terminal **22** have flanges **21***a* and **22***a* that are supported under the cap plate **28**. External circumferential surfaces of upper poles of the first and second terminals **21** and **22**, protruding out of the cap plate **28**, are threaded. In addition, nuts **35** that support the terminals **21** and **22** at upper portions thereof are fastened to respective terminals **21** and **22**.

Gaskets **36** and **39** are respectively installed between the first terminal **21** and the cap plate **28** and between the second terminal **22** and the cap plate **28** so as to seal gaps between the terminals **21** and **22** and the cap plate **28**.

The first terminal **21** is electrically connected to the first electrode **11** through a first lead tab **31**, and the second terminal **22** is electrically connected to the second electrode **12** through a second lead tab **32**.

As a lower insulation member **34** is below the cap plate **28**, lower portions of the terminals **21** and **22** and upper portions of the lead tabs **31** and **32** are inserted into the lower insulation member **34**.

With this structure, the first lead tab **31** electrically connects the first terminal **21** with the first electrode **11** and the second lead tab **32** electrically connects the second terminal **22** with the second electrode **12**.

A short circuit opening **23** is formed in the cap plate **28**, and the deformable plate **43** is inserted into the short circuit opening **23**.

The first tab **41** (or short circuit tab) has a plate shape, and is located on the cap plate **28**. The first terminal **21** is inserted into the first tab **41**, and the first tab **41** is fixed to the first terminal **21** by the nut **35**. Accordingly, the first tab **41** is electrically connected to the first terminal **21** through the nut **35**.

As a conductive connection tab **38** is provided between the second terminal **22** and the nut **35**, the connection tab **38** electrically connects the second terminal **22** and the cap plate **28**. The second terminal **22** is inserted into a hole of the connection tab **38**, and therefore the connection tab **38** is closely adhered to the cap plate **28** through the nut **35** provided thereon.

An upper insulation member **37** is provided between the first tab **41** and the cap plate **28** for insulation therebetween. The upper insulation member **37** partially surrounds the first terminal **21**, and the edge of the upper insulation member **37** surrounds a side end of the first tab **41**. Therefore, the first tab **41** is supported by the upper insulation member **37**, and deformation due to pressure caused by deformation of the deformable plate **43** can be minimized or reduced. Accordingly, the first tab **41** and the deformable plate **43** can maintain a stable connection.

The deformable plate **43** (e.g., inversion plate) is inserted into the short circuit opening **23**, and includes a notch **43***a* formed on a surface thereof, a frame portion **43***b* formed in a flat ring shape and attached to the cap plate **28** by welding, and a deformation portion **43***c* curved in an arc shape and protruded toward the electrode assembly **10**. Accordingly, the deformable plate **43** is electrically connected to the second terminal **22** through the cap plate **28**. The notch **43***a* is broken and emits gas outside when internal pressure of the case **15** is increased beyond a set or predetermined pressure. The notch **43***a* could be a thin portion. In other words, the notch **43***a* could be thinner than the rest of the deformable plate **43**.

In the first tab **41**, a round vent hole **41***a* is formed in a portion corresponding to the short circuit opening **23**. In addition, a hole is formed in a portion of the upper insulation member **37** corresponding to the short circuit opening **23**.

As shown in FIG. **3**A, when the internal pressure of the rechargeable battery **110** is excessively increased, the deformation portion **43***c* that is originally protruded downward is deformed to protrude upward, and the first and second electrodes **11** and **12** are short circuited as the deformation portion **43***a* contacts the first tab **41**.

The deformable plate **43** contacts the first tab **41** along an internal circumference of the vent hole **41***a*, and accordingly, a contact area of the deformable plate **43** and the first tab **41** is large enough to maintain a stable connection.

In addition, as shown in FIG. **3**B, when the internal pressure of the case **15** is further increased after the first and second electrodes **11** and **12** are disconnected, the notch **43***a* of the deformable plate **43** is broken and internal gas is discharged or emitted out of the battery. The gas may be emitted out through the vent hole **41***a* of the first tab **41**.

As described, according to the first exemplary embodiment, when the temperature is increased or the internal pressure of the rechargeable battery **110** is excessively increased due to dissolution of the electrolyte solution, or any other reason, the deformation portion **43***c* induces a short circuit to thereby prevent or minimize the risk of explosion or combustion of the rechargeable battery **110**. The pressure that causes deformation of the deformable plate **43** can be accurately controlled by changing the thickness and shape of the deformable plate **43**.

Particularly, the location where the deformable plate **43** and the first tab **41** contact one another is separated from the electrolyte solution, so that combustion of the electrolyte solution due to flame or heat generated when the short circuit occurs can be prevented. When the short circuit occurs, the current is quickly (e.g., instantaneously) increased so that the internal temperature of the battery may be greatly increased. However, as in the present exemplary embodiment, heat can be emitted out of the case **15**, through the first tab **41**, which is outside the case **15**, so that the accumulation of excessive heat inside the case **15** can be prevented.

An elastic member, such as a spring, continuously receives pressure during normal operation of a battery, and the elasticity of the spring may be decreased or eliminated after a period of time. However, in order to improve long term safety of the rechargeable battery **110**, the elastic member should be capable of operating under a predetermined or set pressure without losing elasticity during an expected life of the rechargeable battery. If the elastic member receives pressure during normal operation of the battery, the elasticity of the elastic member is reduced or eliminated, and thus it may not properly operate during the expected life of the rechargeable battery **110**, thereby causing a safety problem. Therefore, when the deformable plate **43** is used according to the present exemplary embodiment, the elastic member, i.e., the deformable plate **43**, is capable of operating without being deformed under a predetermined or set pressure during normal opera-

tion, so that it may operate under the predetermined pressure for a relatively long period of time.

In addition, when the internal pressure of the case **15** is further increased, the notch **43***a* is broken so that explosion of the rechargeable battery **110** can be prevented. An additional vent member is not required since the deformable plate **43** functions as a vent.

FIG. **4** is a cross-sectional view of a rechargeable battery according to a second exemplary embodiment of the present invention.

Referring to FIG. **4**, a rechargeable battery **120** according to the second exemplary embodiment generally has the same structure as the rechargeable battery of the first exemplary embodiment, except that the rechargeable battery **120** does not include a second terminal. No further description of structures that are similar will be provided.

As shown in FIG. **4**, the rechargeable battery **120** according to the present exemplary embodiment includes a case **15** and a cap assembly **40** that closes and seals the case **15**.

The cap assembly **40** includes a first terminal **21** protruding out of the case **15**, a cap plate **42** combined to an opening of the case **15**, and a first tab **41** electrically connected to the first terminal **21** and provided on the cap plate **42**.

The first terminal **21** extends through the cap plate **42** and protrudes out of the case **15**, and is electrically connected to the first electrode **11** through a first lead tab **31**.

The rechargeable battery **120** also includes a second electrode **12** and a second lead tab **32** electrically connecting the second electrode **12** and the cap plate **42**. A lower portion of the second lead tab **32** is attached to a second uncoated region **12***a* of the second electrode **12** by welding, and an upper portion of the second lead tab **32** is attached to the cap plate **42** by welding.

A short circuit opening **23** is formed in the cap plate **42**. A deformable plate **43** is provided in the short circuit opening **23** and is deformed when the internal temperature of the case **15** is increased and induces a short circuit between the cap plate **42** and the first tab **41**. The deformable plate **43** may include a notch **43***a*, e.g., a thin portion.

A first tab **41**, electrically connected to the first terminal **21**, and including vent hole **41***a*, is formed above the short circuit opening **23**. Thus, when the deformable plate **43** is deformed so that it contacts the first tab **41**, the first and second electrodes **11** and **12** are electrically connected so that a short circuit may occur therebetween.

According to the present exemplary embodiment, the second lead tab **32** is directly attached to the cap plate **42** so that contact resistance between the second terminal **12** and the cap plate **42** can be minimized or reduced.

FIG. **5** is a cross-sectional view of a rechargeable battery according to a third exemplary embodiment of the present invention.

Referring to FIG. **5**, a rechargeable battery **130** according to the third exemplary embodiment has a structure that is generally the same as the rechargeable battery of the first exemplary embodiment, except for the structure of the first tab, and therefore structures that are similar may not be further described.

As shown in FIG. **5**, the rechargeable battery **130** according to the present exemplary embodiment includes a case **15** and a cap assembly **50** that closes and seals the case **15**.

The cap assembly **50** includes a first terminal **21** protruding out of the case, a cap plate **58** combined to an opening of the case **15**, and a first tab **51** electrically connected to the first terminal **21** and provided on the cap plate **58**.

The first terminal **21** and the second terminal **22** extend through the cap plate **58** and protrude out of the case.

A deformable plate **52** that deforms when internal pressure of the case **15** is increased is inserted into a short circuit opening **53** formed in the cap plate **58**. The deformable plate **53** induces a short circuit between the cap plate **58** and the first tab **51**. A notch **52***a* is formed in the deformable plate **53**.

The first tab **51** has a vent hole **51***a*. In this case, a vertical cross-section of an internal surface **51***b* of the vent hole **51***a* is curved in an arc shape so that the interior diameter of the vent hole **51***a* is gradually decreased upward. In other words, a diameter of the vent hole **51***a* decreases from an interior of the case toward the exterior of the case.

As shown in FIG. **6**A, when internal pressure of the rechargeable battery **130** is increased, the deformable plate **52** is deformed upwardly so that it electrically contacts the first tab **51**. In this case, the first tab **51** contacts the deformable plate **52** at the internal surface of the vent hole **51***a*, and the internal surface **51***b* of the vent hole **51***a* is curved in the arc shape so that the curved deformable plate **52** and the first tab **51** may have a large contact area.

As shown in FIG. **6**B, when the internal pressure of the case **15** is further increased, the notch **52***a* of the deformable plate **52** is broken and internal gas may be emitted out of the rechargeable battery **130** therethrough.

FIG. **7** is a cross-sectional view of a rechargeable battery according to a fourth exemplary embodiment of the present invention.

Referring to FIG. **7**, a rechargeable battery **140** according to the present exemplary embodiment generally has the same structure as the rechargeable battery of the first exemplary embodiment, except that a middle member **45** is added to the rechargeable battery **140**. No further description for similar structures will be provided.

The rechargeable battery **140** according to the present exemplary embodiment includes a case **15** and a cap assembly **48** that closes and seals the case **15**.

The cap assembly **48** includes a cap plate **28**, a first terminal **21**, a second terminal **22**, a first tab **41** provided on the cap plate **28**, a deformable plate **47** disposed under a short circuit hole **23** of the cap plate **28**, and a middle member **45** provided between the first tab **41** and the deformable plate **47**.

The first tab **41** is electrically connected to the first terminal **21**, and the cap plate **28** is electrically connected to the second terminal **22**. In addition, the deformable plate **47** is welded to the cap plate **28** under the short circuit opening **23** and is thus electrically connected to the cap plate **28**.

The middle member **45** is thicker than the deformable plate **47**, and is disposed between the first tab **41** and the deformable plate **47**. In addition, the middle member **45** is formed in a cylindrical pipe shape, and has an internal space. When the middle member **45** is welded to the deformable plate, the middle member **45** is welded along a lower end circumference of the middle member **45**. In addition, an upper surface of the middle member **45** is parallel to the first tab **41** so that the middle member **45** can have sufficient contact area with the first tab **41**.

The middle member **45** can be inversely deformed at a set or predetermined pressure level by controlling the weight, thickness, and shape thereof.

Thus, when the deformable plate **47** is deformed to be convex upward, the middle member **45** is lifted and contacts the first tab **41**, and accordingly, the cap plate **28** is electrically connected to the first tab **41** through the deformable plate **47** and the middle member **45**.

A notch **47***a* is formed in the deformable plate **47**, and a middle hole **45***a* is in the center of the middle member **45**, in the internal space. When internal pressure of the case **15** is

further increased, the notch **47***a* is broken and opened, and internal gas is emitted through the middle hole **45***a* and a vent hole **41***a*.

When the deformable plate **47** directly contacts the first tab **41**, the deformable plate **47** may be melted due to an over current, and thus the short circuit may be stopped. This is because the deformable plate **47** may not sufficiently contact, but rather may only partially contact, the first tab **41**.

However, according to the present exemplary embodiment, the middle member **45** can contact the first tab **41** in a sufficient area. As the middle member **45** is welded to the deformable plate **47**, and the middle member **45** has sufficient contact area with the first tab **41**, the short circuit can be continued.

FIG. **8** is a cross-sectional view of a rechargeable battery according to a fifth exemplary embodiment of the present invention, and FIG. **9** is a top view of the rechargeable battery according to the fifth exemplary embodiment of the present invention.

Referring to FIG. **8** and FIG. **9**, a rechargeable battery **150** according to a fifth exemplary embodiment includes an electrode assembly **10**, a case **75** to which the electrode assembly **10** is inserted, and a cap assembly **60** closing and sealing the case **75**. The electrode assembly **10** includes a first electrode **11**, a second electrode **12**, and a separator **13** interposed between the first and second electrodes **11** and **12**. The cap assembly **60** includes a cap plate **76** combined to an opening of the case **75**, a first terminal **71** electrically connected to the first electrode **11**, and a second terminal **73** electrically connected to the second electrode **12**.

The cap plate **76** is formed of a thin plate, and has a short circuit opening **76***a* in a center thereof.

In addition, a first tab **61** electrically connected to the first terminal is provided at the first terminal **71**, and the first tab **61** has a protrusion **61***a* inserted into the short circuit opening **76***a*. A second tab **62** is provided at the second terminal **73**, and the second tab **62** has a protrusion **62***a* inserted into the short circuit opening **76***a*.

In the present exemplary embodiment, the first terminal **71** and the second terminal **73** are formed in a rivet shape.

The first terminal **71** is electrically connected to a first electrode uncoated region **11***a* through a first lead tab **71***a*, and the second terminal **73** is electrically connected to a second electrode uncoated region **12***a* through a second lead tab **73***a*. Gaskets **74** are provided between the terminals **71** and **73** and the cap plate **76** for sealing and insulation.

The first tab **61** (e.g., first short circuit tab) and the second tab **62** (e.g., second short circuit tab) are inserted into the short circuit opening **76***a* on the cap plate **76** through an insulation member **78** and thus they are electrically insulated from the cap plate **76**, and accordingly the cap plate **76** and the case **75** do not have electrical polarity.

The first terminal **71** and the second terminal **73** are located on respective edges of the cap plate **61** along the longitudinal direction. One end of the first tab **61** is inserted into the first terminal **71**, and the other end thereof having the protrusion **61***a* is inserted into the short circuit opening **76***a*. One end of the second tab **62** is inserted into the second terminal **73**, and the other end thereof having the protrusion **62***a* is inserted into the short circuit opening **76***a*.

In the short circuit opening **76***a*, the first tab **61** and the second tab **62** are disposed at a distance from each other, and the ends of the protrusions **61***a* and **62***a* are substantially formed in an arc shape. A deformable plate **63** is provided below the short circuit opening **76***a*, and a notch **63***a* is formed in the deformable plate **63**.

When internal pressure of the rechargeable battery **150** is increased, the deformable plate **63** is deformed and lifted upward so that the first and second tabs **61** and **62** are electrically connected. When the internal pressure of the rechargeable battery **150** is further increased while the battery is short circuited, the notch **63***a* is broken and internal gas is emitted out of the rechargeable battery **150** therethrough.

As described, according to the present exemplary embodiment, when pressure in the battery is increased, the first and second tabs **61** and **62** are electrically connected to thereby prevent explosion of the battery due to an excessive increase of internal pressure. The first and second tabs **61** and **62** are located outside the case **75** so that excessive internal heat generation in the rechargeable battery **150** due to a short circuit current is prevented or reduced.

In addition, a current does not flow through the cap plate **76** so that overheating of the cap plate **76** can be prevented or reduced. Further, since the first and second tabs **61** and **62** are located outside the case **75**, heat can be easily emitted out through the first and second tabs **61** and **62**. Furthermore, as the first and second tabs **61** and **62** are separated from the electrolyte solution in the battery, combustion of the electrolyte solution can be prevented.

While this disclosure has been described in connection with certain exemplary embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims, and equivalents thereof.

What is claimed is:

1. A rechargeable battery comprising:

an electrode assembly comprising a first electrode, a second electrode, and a separator between the first electrode and the second electrode;

a case containing the electrode assembly; and

a cap assembly coupled to the case, the cap assembly comprising a cap plate, the cap plate having a short circuit opening, a first tab electrically coupled to the first electrode, the first tab being at an exterior of the case, and a deformable plate covering the short circuit opening, the deformable plate comprising a first portion and a second portion that is thinner than the first portion, the deformable plate being configured to form an electrical path between the first electrode and the second electrode by directly or indirectly contacting, the first tab when deformed.

2. The rechargeable battery of claim **1**, wherein the cap assembly further comprises a first terminal electrically coupled to the first electrode and mounted on the cap plate, wherein the first tab is electrically connected to the first terminal.

3. The rechargeable battery of claim **2**, wherein the first tab has an opening through which the first terminal protrudes from an interior to an exterior of the case.

4. The rechargeable battery of claim **1**, wherein the cap assembly further comprises an insulating member between the first tab and the cap plate for electrically insulating the first tab from the cap plate, wherein the insulating member includes an opening to accommodate upward deformation of the deformable plate.

5. The rechargeable battery of claim **1**, wherein the first tab comprises a protrusion which is at least partially inserted into the short circuit opening.

6. The rechargeable battery of claim **1**, wherein the second electrode is electrically coupled to the cap plate.

7. The rechargeable battery of claim **1**, wherein the deformable plate is curved to protrude toward an inside of the case.

8. The rechargeable battery of claim 1, wherein the deformable plate is configured to break and open at the second portion in response to an increase in pressure inside the case.

9. The rechargeable battery of claim 1, wherein the first tab has a vent hole.

10. The rechargeable battery of claim 9, wherein a diameter of the vent hole decreases from the interior of the case toward the exterior of the case.

11. The rechargeable battery of claim 1, further comprising a middle member between the first tab and the deformable plate and attached to the deformable plate.

12. The rechargeable battery of claim 1, further comprising a first terminal, a second terminal, and a second tab, the first tab being connected to the first terminal and the second tab being connected to the second terminal, the deformable plate being configured to deform and electrically contact the first tab and the second tab in response to an increase in pressure inside the case.

13. The rechargeable battery of claim 1, wherein the second portion is at the center of the deformable plate.

14. The rechargeable battery of claim 1, wherein the second portion comprises a notch.

15. A rechargeable battery comprising:

an electrode assembly comprising a first electrode, a second electrode, and a separator between the first electrode and the second electrode;

a case containing the electrode assembly; and

a cap assembly coupled to the case, the cap assembly comprising a cap plate, the cap plate having a short circuit opening, a first tab electrically coupled to the first electrode, the first tab being external to the case, and a deformable plate covering the short circuit opening, the deformable plate being configured to deform and break to allow gas to exit the case, the deformable plate being configured to form an electrical path between the first electrode and the second electrode by directly or indirectly contacting, the first tab when deformed.

16. The rechargeable battery of claim 15, wherein the cap plate has a vent hole configured to allow gas to exit the case when the deformable plate breaks.

17. A rechargeable battery comprising:

an electrode assembly comprising a first electrode, a second electrode, and a separator between the first electrode and the second electrode;

a case containing the electrode assembly; and

a cap assembly coupled to the case, the cap assembly comprising a cap plate, a first terminal, a second terminal, a first tab electrically coupled to the first electrode and connected to the first terminal, a second tab connected to the second terminal, and a deformable plate comprising a first portion and a second portion that is thinner than the first portion, the deformable plate being configured to deform and electrically contact the first tab and the second tab in response to an increase in pressure inside the case,

wherein the cap plate has a short circuit opening, and wherein a first end of the first tab is connected to the first terminal and a second end of the first tab is in the short circuit opening and a first end of the second tab is connected to the second terminal and a second end of the second tab is in the short circuit opening.

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